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ABSTRACT

The effects of mastery learning strategies, interactive video mathematics (IVM), individualized instruction (IND), and the lecture method on mathematics achievement of community college students was studied. Interactions among instructional methods, gender, and age were examined; and the grade success rate was determined for each instructional method. The IND and IVM methods were characterized by mastery learning principles. Pretest and posttest components determined the mathematics achievement of college freshmen. Of 377 students enrolled in basic skills mathematics courses at an urban multicampus two-year community college for whom pretest results were available, complete data were obtained for 137 adults aged over 22 years and 82 traditional students aged 17 to 22 years. The efficacy of the methods was compared, and a final grade success rate was determined for each group using chi-square for testing significant differences. IVM and IND methods had a positive educational influence on students' achievement on mathematics basic skills posttest scores, but, because many of these students did not complete the course in 10 weeks, grade success rate was significantly lower for these methods than for the lecture method. No significant difference was found for gender on the main effects, but a significant difference for simple effects shows that males favor the IVM method. Those over 22 years old had higher achievement than did those in the traditional college age group. Six tables present study data. (SLD)

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EFFECTS OF MASTERY LEARNING STRATEGIES ON COMMUNITY COLLEGE MATHEMATICS STUDENTS' ACHIEVEMENT AND SUCCESS RATE

By

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ABSTRACT

The purposes of conducting this investigation were (a) to examine the effects of mastery learning strategies, interactive video mathematics (IVM), individualized instruction (IND), and the lecture method on community college students' achievement in mathematics, b) to determine if there were interactions among instructional methods, gender, and age, regarding achievement, and c) to determine grade success rate for each instructional method.

The study was designed with pre-post tests components. The efficacy of IVM and IND for unprepared two year college freshmen was explored by ANOCOV design. Also an analysis was made for all students who participated in the study by calculating the final grade success rate for each group using chi-square for testing significant differences.

There was significant difference which suggested that IVM and IND learning strategies have a positive educational influence on students' achievement on mathematics basic skills posttest scores. However, due to the fact that many IVM and IND students were not able to complete the course in ten weeks, grade success rate was significantly lower than it was in the lecture method.

No significant difference was found for gender on the main effects, however a significant difference was found on the simple effects, showing that males favored the IVM method of instruction. Concerning students' age, adults (age higher than 22) achieved significantly higher than traditionally aged students.

It was reported that one-third of all entering college freshmen need remediation in mathematics (Plisko & Stern, 1985). Since studies by (Anderson, 1983; Block, 1971; Block & Burns, 1976; Imels, 1989; Slavin, 1987) showed that mastery learning strategies and personalized systems of instruction (PSI) independently have large effect sizes, there was a need to study mastery learning combined with a type of personalized system of instruction, such as IVM instruction. The present study extended the Slavin (1987) studies by combining mastery learning methods with interactive video mathematics technology which used not only computers but also laser vieodiscs.

The fact that personalized systems of instruction which include IVM methods are presently in the forefront of attention serves to revive an older, unresolved research problem in a new context, and has greater potential for solution. Therefore, the task was to determine which process of learning is superior: Teacher-paced traditional lecture instruction which places the learner in a position of complete dependence on the teacher, or mastery learning in which the learners progress according to their own pace, participate in setting up their goals, and in grading their exams. The effects of the combination of mastery learning and IVM for remedial mathematics college students posed one of the main questions of this study.

In light of the large population required to study

remedial mathematics in this college, and since this two year college, where the study was conducted, has been extensively using mastery learning techniques, there was a need to examine mastery learning strategies for instructional competence and distinguish effective methods of instruction that promote mathematics learning. Strategies available to students, and the efficiency with which they can be performed are important issues for the study of instructional mathematics methods.

METHOD

This study was conducted with 377 mathematics basic skills freshmen college students in a northeast Ohio two year community college over three consecutive academic quarters starting Spring 1991. The data reported in this study for student's academic performance are the result of combining the raw data for the three quarters. The students differ in their academic background, socioeconomic status, and gender. Their ages ranged from 18 to 74 years. This college has been using the IVM strategy for four years while IND and lecture strategies have been used in this two year college for a period which exceeds 15 years.

This study employed a pre-post design (Campbell & Stanley, 1966). The control group consisted of students taught by the lecture method of instruction. The experimental group consisted of students taught by mastery learning methods of instruction based on Bloom's theory

(Bloom, 1981). One of the two experimental groups was taught by individualized instructional methods and the other group was taught by interactive video mathematics by using a computer and laser videodisc.

All instructors in this college have the experience to teach mathematics basic skills by any of the three methods. Students register for the method according to their time schedule. Instructional strategies were the independent variable. The dependent variable was achievement. Pretests scores were used in an analysis of covariance statistical design (Pedhazur, 1982) to control for initial group differences. A quasi-experimental research design with ANOCOV was employed because subjects could not be randomly assigned to treatment groups. Academic performance in the present study was assessed by two measures; one was a quantifying posttest score for achievement for those students who completed the mathematics basic skills course, and the other was the mathematics course grade which was used to measure success rate for all students who started the course.

Description of Methods of Instruction

Lecture Strategy. In the lecture format, one instructor is assigned to a section consisting of 30-35 students, and all students are expected to progress at the same rate and take exams in the same time as designated by the instructor. Instructors grade the exams, but do not necessarily provide

feedback to the students about what they have missed in the test, nor are there make up exams. Teachers lecture and direct instruction to meet the objective of the planned curriculum.

Individualized strategy. In the individualized strategy at this community college, there are no lectures and the instructor is expected to be a facilitator of learning. Students have to seek information, ask questions, discover methods to problem solving, interact with other students in their group, with their tutor, their instructor, with text book, and participate in evaluating their own progress. Students progress through the course material at their own pace. Skills that a student already has mastered can be skipped at the student's discretion.

An individualized strategy class contains about 40 students, one instructor, one lab assistant, and five tutors. Students are divided into five groups, each of which has a tutor. Tutors answer students' questions, and guide them according to their different needs. Most instruction is given by tutors and it occurs individually depending on the student's need. The students complete prescribed text chapters, based on pretest scores. If students pass a pretest with at least 80% correct answers, and their tutor explains the ones they have missed, they can proceed to the application problems in the same chapter and then solve the chapter test. The tutor is responsible for

grading the chapter tests. When students complete the assignment for one unit, the tutor checks their work. If students obtain a score of at least 80% in the assignment, they may take the test which corresponds to the unit they have mastered. The lab assistant administers the tests and delivers them to the instructor. The instructor immediately corrects the unit exams, and explains to students what they missed on the test. If a score of at least 80% is not earned, more problems are assigned and have to be solved before the student is allowed to retake the test.

The Interactive Video Mathematics Strategy IVM. IVM is an individualized personalized type of instruction. IVM combines the applications of computer-based education, computer-managed instruction, drill and practice, and tutorial. The instructor here is called "facilitator of learning" (Dembo, 1988). The modern teacher is transformed from a knowledge dispenser to an arranger of optimal learning experiences. Instructors need to be prepared for these changes because in many cases the teacher will not present information to students. Instead, they may be spending more time diagnosing the learning problems and deciding on alternative learning methods.

With IVM, a variety of media and delivery options are possible in one comprehensive package. The controlling program is on an external computer which contains at least three hard-ware components. In an IVM lab, instruction

occurs through the interaction of a student with a computer and laser videodiscs. The work station for a student contains: a computer, a user-response device (touch--sensitive screen, keyboard, or mouse), computer ear-phones, a videodisc player, and one or more monitors that display videodisc, computer based material, and courseware. The courseware consists of videodiscs, computer software, and related manuals or guides. The computer runs the software program to read information from the videodisc and display it on the monitor, which resembles a television screen. The developer is able to mix voice, video, text and dynamic graphics, including animation.

In the first class meeting, objectives of the course are explained. Every student performs a placement test through the IVM work station. The results of this placement test determines the number of units or modules that a student is required to complete. As in IND, students progress through the course material at their own pace, take tests when they feel ready, and participate in grading their own papers.

In the IVM method, the instructor usually introduces the student to the hardware and software. This introduction should emphasize how students can best use the available instructional tools to suit their own learning styles, and depending on students' request, instructors review their progress, schedule unit exams, discuss problems and plan

work in future modules.

Through IVM, instruction is provided mainly by the computer, which is a natural technical source, where teachers personality factors are not likely to interfere with the effectiveness of the instruction. Students may realize that they are in control of the learning environment which results in having a great deal of motivational value. However, because of the nature of the software, students cannot move to the next unit unless they master the previous unit with a score of at least 80%.

The following characteristics are the same for the three methods of basic mathematics instruction at this community college: (a) objectives and goals of the subject, (b) subject matter is divided into small units, (c) students are required to take an exam at the end of every unit, (d) all students take four unit exams and a comprehensive final exam, (e) all students take the same final exam, and (f) depending on the student average score out of 100, for the five exams, each student receives one of the grades: A, B, C, D, F, IN, or W.

Population

The present study was conducted with students enrolled in mathematics basic skills courses at the metropolitan campus of an urban multi-campus two year community college in northeastern Ohio. The college is an open-enrollment institution serving over 40,000 students annually.

The college provides education to every person seeking education-without regard to race, ethnic origin, religion, sex, handicap or level of income. Students' average age was reported to be 30.9.

Upon admission, every student is required to take a placement test. In this study students scores on the Mathematics Placement Test level 1 were lower than a raw score of 18 out of 32. The IVM group consisted of a total of 103 students, IND consisted of a total of 150 students, and the traditional group consisted of a total of 124 students. There are four different forms of each exams and all exams are kept in the mathematics department. Each exam consists of twenty problems. All students were encouraged to seek help in the mathematics lab during open tutoring hours.

To measure achievement, adjusted posttest means were used to compare the three groups. Data were used for only those 219 students who completed the course and took the posttest.

Success rate was measured for 377 students who started the course. Instructors used the average score of the four unit exams and the posttest score to determine the students' final letter grade.

Instructional Procedures

The instruction delivery mode was different for each of the three methods of instruction. The lecture method of

instruction was conducted by an experienced teacher, the IND method of instruction was guided by a tutor, and the IVM method instruction was facilitated mainly by the use of the computers and videodiscs.

The IND and IVM methods were characterized by the following mastery learning principles (Bloom, 1981):

1. Objectives were defined, a pretest was given to determine the number of units a student was required to complete.

2. Students progressed at their own pace.

3. The content was divided into small learning units comprising one to two weeks of instructional time.

4. Unit tests were given to determine student's progress.

5. A high level of performance was required (usually 80% correct) on each formative test before the student could move to enrichment activities or another instructional unit.

6. Students who did not master the material were engaged in corrective work. Students were provided with alternative learning resources such as additional lectures, small group instruction, or filmstrips.

7. All students are allowed to retake exams.

8. After the student has passed all unit exams, the teacher administers a summative test covering the objectives of all the units.

Materials of Instruction

The recommended textbook was Basic College Mathematics by Tobey & Slater (1991) published by Prentice-Hall, Englewood Cliff, New Jersey. IVM students used . "Mathematics One" software programs by Ferranci Educational Systems.

Organization of Content

For the three instructional methods, the contents of the mathematics basic skills program were the four basic operations (addition , subtraction, multiplication, and division) for decimals, and fractions, as well as the metric system, percentage, and pre-algebra. At the end of every topic, there were assigned application problems.

Each chapter in the textbook contained a pretest, skill problems, application problems, and a chapter test.

To measure grade success rate, a measure similar to the measure used by Jones, Gordon, & Schechtman (1975) was used. The number of succeeding students with any of the grades A, B, C, or D was found in each instructional method for the three quarters combined. This number was compared to the number of students who earned any of the grades A, B, C, D, F, or W in the three instructional methods for the three quarters combined.

RESULTS

Analysis of Student Achievement

An ANOCOV, as shown in Table 1 was completed to test

for significant differences among mathematics instructional methods for two year community college students regarding achievement. ANOCOV was used for raw data obtained for the three quarters combined with pretest scores as covariate.

Table 1

Achievement Posttest Adjusted Means Using ANOCOV

Source	df	MS	F
Covariates mathpre	1	601.689	29.330*
Main Effects	4	83.925	4.091*
Instr Meth	2	72.250	3.522*
Gender	1	08.587	.419
Age	1	161.138	7.855*
2-Way Interactions	5	53.986	2.632*
Inst Meth x Gender	2	128.406	6.259*
Inst Meth x Age	2	5.094	.248
Gender x Age	1	14.802	.722
Residual	206	20.514	
Total	218	25.334	

*p < .05

Table 1 shows that the significant results on the pretest means indicated that differences among the groups existed at the start of the treatment.

There were significant difference among the adjusted

achievement posttest means for instructional methods, and for age. Also Table 1 shows that while there was no significant differences concerning gender, there was a two-way interaction for instructional methods and gender concerning achievement.

Table 2 shows that the significant differences among methods of instruction were in favor of mastery learning methods IVM and IND. The achievement adjusted posttest means were higher for mastery learning methods especially the IVM.

Table 2

Achievement Posttest Adjusted Means and Instruct. Methods

	Post-test Adjusted Means	N
IVM	23.57	56
IND	23.27	78
Lecture	21.09	85
Total		219

In this study, there were 137 adults (older than 22 years) and 82 traditional students (age 17-22). The adjusted means are shown in Table 3. Adults achieved higher than the traditional students for the three quarters combined.

Table 3

Achievement Posttest Adjusted Means and Students' Age

	Posttest Adjusted means	N
Age 22 and younger	21.48	82
Adults: age above 22	23.09	137

Table 4 shows that for the three quarters combined, males achieved higher in the method of IVM while females achieved higher in the methods of IND and lecture.

Table 4

Interaction of Gender and Instruct. Methods on Adjusted Posttest Means

	Total N	n Male	n Fem.	Male Adj. Mean	Fem. Adj. Mean
IVM	56	18	38	26.4	22.2
IND	78	19	59	22.6	23.5
Lec	85	23	62	20.4	21.4

Since analysis of the interactions of instructional methods and gender was significant and the number of students was different in each group, Scheffe' test was used to investigate the simple effects of gender and of instructional methods.

Table 5 shows significant difference was found among

males achieving higher in IVM than lecture method. No significant difference was found among females for instructional methods.

Table 5

ANOVA on Math Achievement and Instructional Methods for Males

Source	df	SS	MS	F
Between	2	372.2396	186.1198	6.91*
Within	57	1534.3438	26.9183	
Total	59	1906.5833		

*p < .05

Analysis of Student Success Rate

To test success rates for the three methods, chi-square was used with two degrees of freedom for the three quarters combined. A total of 377 students took the mathematics pre-test. At the end of the academic term, 204 students received a grade of A, B, C, or D. One hundred seventy three students received a grade of F or W. Table 6 shows the number of students who passed the course with one of the grades: A - D and number of students who obtained a grade of F or W for every instructional method.

Chi-square was found to be 8.15. Chi-square was used to test for significant differences regarding success rate among instructional methods.

Table 6

Number of Students Passing or Failing and Success Rate

	A - D	F & W	Total N	Rate of Success
IVM	50	53	103	48.5
IND	74	76	150	49.3
Lect	80	44	124	64.5

There were significant differences between methods of instruction regarding success rate in favor of lecture method.

DISCUSSION

The study addressed the following questions:

1. Is mathematics achievement posttest means significantly different for any of the instructional strategies?

2. Is mathematics achievement posttest means significantly different for adults and traditional aged students?

3. Is mathematics achievement posttest scores significantly different for males and females?

4. Is there interaction between instructional methods, age, and gender when considering mathematics achievement?

5. Are grade success rates significantly different for any of the instructional strategies?

The following four significant results were found.

1. Instructional methods had significant main effect differences on student's achievement as measured by the adjusted posttest means in favor of the mastery learning methods and especially the IVM method. Mastery learning seemed to be an effective teaching strategy. The higher achievement attributable to mastery learning was similar to other researcher's findings (Bangert, Kulik, & Kulik, 1983; Block & Burns, 1976; Bloom, 1984; Guskey & Gates, 1986; Olson, 1988).

The results of IVM instructional method generating higher scores on the achievement posttest than lecture method may be due to the fact that each student in this group was required to earn a score of at least 80% in every unit test in order to advance to the next objective. Students earned less than 80% had to go through the correction-feedback process and then be allowed to retake the test. This was different from the lecture method where the process of correction-feedback was not implemented, and retaking a test was not allowed by all lecture method's instructors. Furthermore, because of the cumulative nature of the information in the lecture method, students who failed to master the material in the first unit were more likely to have problems mastering the material in the second, third, and succeeding units (Bloom, 1984). Lecture students may move on to the next unit regardless of the

score they earned in the previous unit and without making sure that they understood the subject. Thus as the course proceeded, some students may have mastered less material than the mastery learning group. However it seems that in the mastery learning methods, only those students who were able to persevere and spend time on the correction-feedback process and retake tests were able to earn a high score on the posttest. This result is in agreement with Coombs (1975) who found that students achieved better in the individualized method than in the same course using the traditional method, but the individualized instruction did not assure successful completion of the course.

2. The result of adults achieving higher scores on the achievement posttest measure than the traditional aged students is strengthened by the findings of Elliott (1989), and Schonberger (1985). This higher achievement by adults is due to the fact that adults usually have very clear objectives based upon their life experiences or job requirements. These clear objectives cause adult learners to be more motivated toward achievement (Cross, 1981). Some traditional aged students attend college with no clear cut goals set, whereas adult learners attend college with very specific reasons in mind.

3. Table 6 shows that males obtained higher posttest scores with the IVM method than they did with the two other methods. This result of men achieving higher scores by

using the computer (machine) is consistent with Gilligan (1982) who believed that autonomy and isolation are qualities attributed to men and affiliation is a quality that is attributed to women. IVM strategy does not allow for much interaction with personnel. This result may be explained as the difference between the instrumental and affective domains which is regarded as a cultural influence on human development for two types of adaptation. Men tend to work with machines and be independent (Smelser & Erikson, 1980). On the other hand, women traditionally tended to raise children and if they worked outside home, women would prefer to work with personnel.

4. There were significant differences in grade success rate in favor of the lecture method. The result of higher success rate with the lecture students is in agreement with data obtained through the computer system for all 452 students who registered for the course mathematics basic skills for Fall 1991. Success rate for lecture students was 60% while success rate for mastery learning students was 49.7%. This data was distributed to the mathematics faculty, lab assistants and tutors at CCC early Winter 1992 (College Bound Staff, 1992).

One reason mastery learning students may have had a lower grade success rate than the lecture students is the fact that mastery learning students must achieve 80% or higher in every unit before they start to learn new skills.

With IVM instruction, where students learn mainly by the machine, a given point should be thoroughly understood, otherwise the machine would not start the next objective. This procedure takes a lot of time and may prevent students from completing all objectives in 10 weeks. As a result, many IVM and IND students stopped attending class or dropped out of the course.

It seems that in the lecture method, the majority of students were able to receive a grade from A - D while in mastery learning methods, only those students who were able to spend extra time and stay in the system were able to take the achievement posttest and obtain a high score on the posttest and more likely to earn a high grade for the course.

The question here becomes should educators accept this situation with a scarcity of real skills but large number of graduates? Samuelson (1992) states that "the message here is not only how many students graduate from college, but how hard they work. What we need to improve most is quality, not the number of degrees we produce" (p. 75).

Cox and Dunn (1979) explain that there is a difference between earning a passing grade in a course and mastery of the material. The main issue here seems to be that more instructional time is necessary for the majority of mastery learning students to advance to the next higher level. Only mastery learning students who spent extra time on

assignments were able to succeed and achieve scores of 80% or higher. This finding is supported by Carroll (1963) who stated that most students have the ability to learn what is presented in school, but they differ in the time it takes them to learn the material. Arlin (1984a) states that the time needed to bring slow learners up to the mastery level must come from somewhere. When corrective procedures are accomplished during regular class time, then content coverage may have to be reduced.

In conclusion, although this study confirmed Bloom's theory in which mastery learning students and in particular IVM students were able to achieve academically, the majority were not able to advance to the next higher level because every student was required to earn a grade by the end of the academic session.

However, today, IVM technology provides the vehicle for effectively presenting most instructional components. In order to increase success rates, teachers should always remind the students of the due date for every unit exam, participate with students in setting up unit test days, and encouraging them to do the homework problems.

CONCULUSIONS

1. Because of the nature of the software program, the IVM lab assistant should adjust the program according to students' needs and help the students who are interested to earn a grade by the end of the academic session to skip

unnecessary parts such as fun games or very long division problems. Usually fun games are tricky and may take more than two class periods to understand. the IVM lab assistant must be available at all times to adjust the machine for students who had to repeat a certain module because they missed typing a comma, leaving a space or inserting a bracket. A math tutor should be available to answer students questions so they can move on to the next subject.

2. Table 1 shows no significant gender differences, educators must not assume a gender difference in which males achieve more than females in mathematics.

3. Traditional aged students should be encouraged to interact with adult students and learn from the adults' experience.

4. A description of the three methods of instruction should be made available to students at the time of registration, so students may choose the method which suits their age, gender, and learning style.

5. In lecture method, in order to increase achievement, it is recommended that educators allow students to discuss problems and encourage classroom discussions in general. Mathematics becomes useful to a student only when it has been developed through a personal intellectual engagement that creates new understanding. Most students cannot learn mathematics effectively by only listening and imitating (National Research Council, 1989). Students

should work in groups, engage in problem solving, and make presentations. It was reported that "the least effective mode for mathematics learning is the one that prevails in most of America's classrooms: Lecturing and listening. Students simply do not retain for long what they learn by initiation from lectures, or routine homework" (National Research Council, 1989, p. 57).

6. It is recommended that lecture students should conform with the process of correction-feedback. If class time is too short to allow this process, students should ask the tutors to help them understand all test problems during open tutoring times. This would require changing the tests every academic season. However with today's technology and by using the proper software, several different forms could be generated.

7. In all three methods, students should keep the unit exams with them so they can use them as learning tools.

8. For further research, qualitative research methodology which involves interviews with students is recommended to examine the effectiveness of the three instructional methods on students' attitude toward mathematics.

9. Further research should be conducted to investigate the possibility of combining mastery learning methods with teacher deciding unit tests dates and introducing mini-lectures. Many students may need the teacher to motivate

them and direct them to take the unit tests.

10. Extended parallel mastery learning studies should provide evidence of additional factors which influence students' learning for mastery, such as students learning style, and removing the time barrier.

11. Further research is recommended to find the interaction of gender, age, and instructional method, regarding success rate.

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